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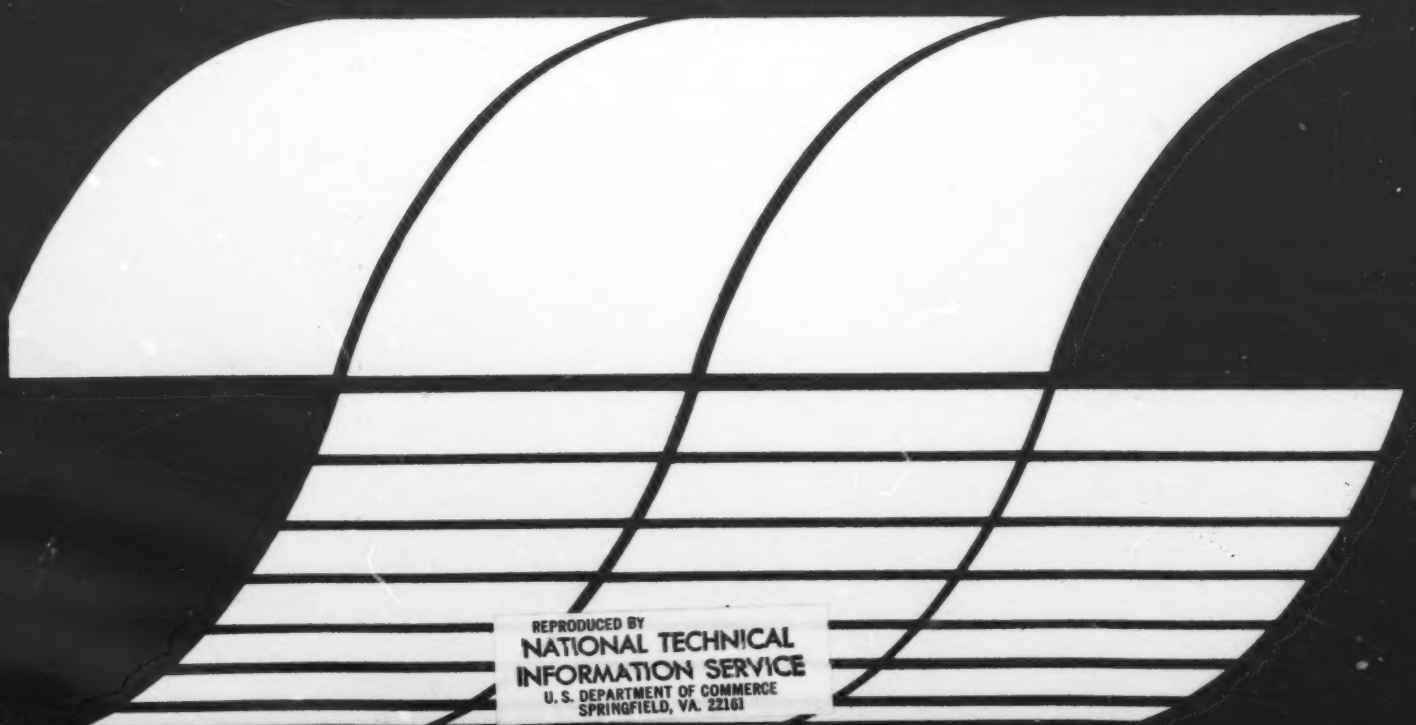
ENVIRONMENTAL ASSESSMENT OF LOW/MEDIUM-BTU GASIFICATION: ANNUAL REPORT

Interagency
Energy-Environment
Research and Development
Program Report



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16. ABSTRACT

The report summarizes completed and on-going work performed by Radian Corporation for the EPA in the area of environmental assessment of low- and medium-Btu gasification of coal and its utilization. Main areas discussed are the current process technology background, environmental data acquisition, and control technology assessment. Information presented gives a general understanding of what has been accomplished and what can be anticipated.

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Washington, D.C. 20460

ABSTRACT

Radian Corporation of Austin, Texas, is under a three-year contract to the United States Environmental Protection Agency to perform an environmental assessment of low/medium-Btu gasification technology.

Work performed by Radian during the first half of the program is summarized in this annual report. Activities in three major task areas are addressed:

1) Current process technology background - the gathering, classifying, and assessing of available information on low/medium-Btu gasification.

2) Environmental data acquisition - the planning for and execution of environmental tests at operating low/medium-Btu gasification facilities.

3) Control technology assessment - identifying control technology needs and selecting applicable emission control processes.

Efforts have been concentrated in the current process technology background task area, but have now shifted to the environmental data acquisition task. Future emphasis will be placed on data acquisition and control technology assessment.

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SECTION 1.0

INTRODUCTION

Radian Corporation of Austin, Texas, is under a three-year contract to the United States Environmental Protection Agency to perform an environmental assessment of low/medium-Btu gasification technology. The program is being directed by the EPA's Industrial Environmental Research Laboratory at Research Triangle Park, North Carolina (IERL/RTP). The work performed by Radian Corporation from the start of the program in March 1976 through October 1977 is summarized in this annual report.

1.1 EPA ASSESSMENT PROGRAMS

Radian's low/medium-Btu technology assessment program is one of a number of environmental assessment programs for fossil fuel conversion technologies being conducted by the IERL/RTP. These programs, when fully developed, will provide technical support to EPA's standard setting and regulatory functions. Through these efforts, control technology needs will also be identified.

The overall goal of the EPA in this program is to define:

1) potential emission sources of environmental concern in fossil fuel conversion facilities,

2) the effectiveness and cost of controlling those emissions to varying levels through the application of candidate control methods, and

3) areas in which existing controls appear to be inadequate for purposes of controlling hazardous pollutant emissions to acceptable levels.

1.2 TECHNICAL OBJECTIVES

The overall technical objectives of the low/medium-Btu gasification environmental assessment program are

1) to perform a comprehensive multimedia environmental assessment of coal gasification processes which produce, and end-use options which consume, low/medium-Btu gases, and

2) to define the control techniques which will have to be applied to guarantee the environmental acceptability of this technology.

Ultimately, it is intended that specific methods will be developed as part of this study which would provide the means of defining the environmental impacts and environmental control needs as functions of design and operating parameters. In other words, a predictive capability would be developed as a result of studying the effects of such things as feedstock properties, process configurations, operating conditions, and regulatory constraints on waste stream compositions and control needs.

SECTION 2.0

SUMMARY OF PROGRESS

During the first half of this three-year program, considerable effort was concentrated on gathering and classifying information on low/medium-Btu gasification technology. Data available from all known sources - literature, process operators, consultants, and so forth - were collected in a technical library. Information from this library was then used to formulate a data base in which the primary process functions and their potential environmental impacts are defined. At this point, much of the gathering of existing data and process analysis work is complete. Progress in these areas is reported under 2.1, Current Process Technology Background.

The next key step in the program is data acquisition. This work is well underway and it will continue to receive major emphasis during the last half of the program. Through development of the data base, the significant low/medium-Btu processes were identified as were the points at which environmental problems were most likely to occur. Plant sites suitable for field testing were located and specific environmental tests were planned for those for which access could be obtained. In support of these data acquisition activities, methodologies were developed for test planning, sampling, analysis, and interpretation, and then assembled into a procedures manual tailored specifically for environmental investigations. Progress of these activities is reported under 2.2, Environmental Data Acquisition.

The final planned phase of this program is control technology assessment. While little can now be reported on this segment of the program, it will receive more emphasis as the results of field testing are reported. Some aspects of control technology are known; raw gas cleaning methods for sulfur cleanup and particulate removal have been reported. The difficult areas are those for which the environmental problems themselves have not yet been defined: cyanide and phenol contents in wastewater emissions; potentially hazardous components in fugitive emissions; potentially hazardous materials in solid waste and particulates; and so forth. Information from environmental test programs will help reveal the true impact of such pollutants and will, in the final analysis, dictate the control technology required for each source. The limited results from this part of the program are reported under 2.3, Control Technology Assessment.

2.1 CURRENT PROCESS TECHNOLOGY BACKGROUND

Through October 1977, Radian's activities in this area included 1) conducting an extensive literature search and establishing a readily accessible reference library and data base, 2) performing engineering analyses of low/medium-Btu gasification processes, and 3) providing general support to the EPA for coal gasification.

2.1.1 Technical Information Files

The data base for low/medium-Btu technology is, in fact, a compilation of usable data, assembled in a useful manner. An investigator who wishes to initiate an environmental assessment program for a given process, e.g., a Wellman-Galusha gasifier, must first be able to assemble all pertinent data (operating, cost, environmental, etc.) on this process before he can intelligently plan a test program.

For this reason, it was important to develop an efficient system for cataloguing, storing and accessing information contained in the data base. Radian's data base for the low/medium-Btu gasification environmental assessment program is maintained in a dedicated library. This library houses 1) the technical information files, 2) card catalogues for accessing information by an assigned reference number, author or subject, and 3) news releases on current developments in low-Btu gasification and related technologies.

An extensive survey was initiated early in the program to identify information available on low-Btu technology. Emphasis was placed on topics such as gasification, gas cleanup, pollution control and environmental regulations. Test methods, including sampling and analytical techniques, were also given strong emphasis.

The information survey involved manual screening of selected abstracting and indexing publications. Computerized on-line literature searches of selected topics were conducted. Agencies, institutions, companies and experts were contacted. Special searches in other areas of interest were conducted when required. A simplified flowsheet showing Radian's technical literature handling system is presented in Figure 2-1. An

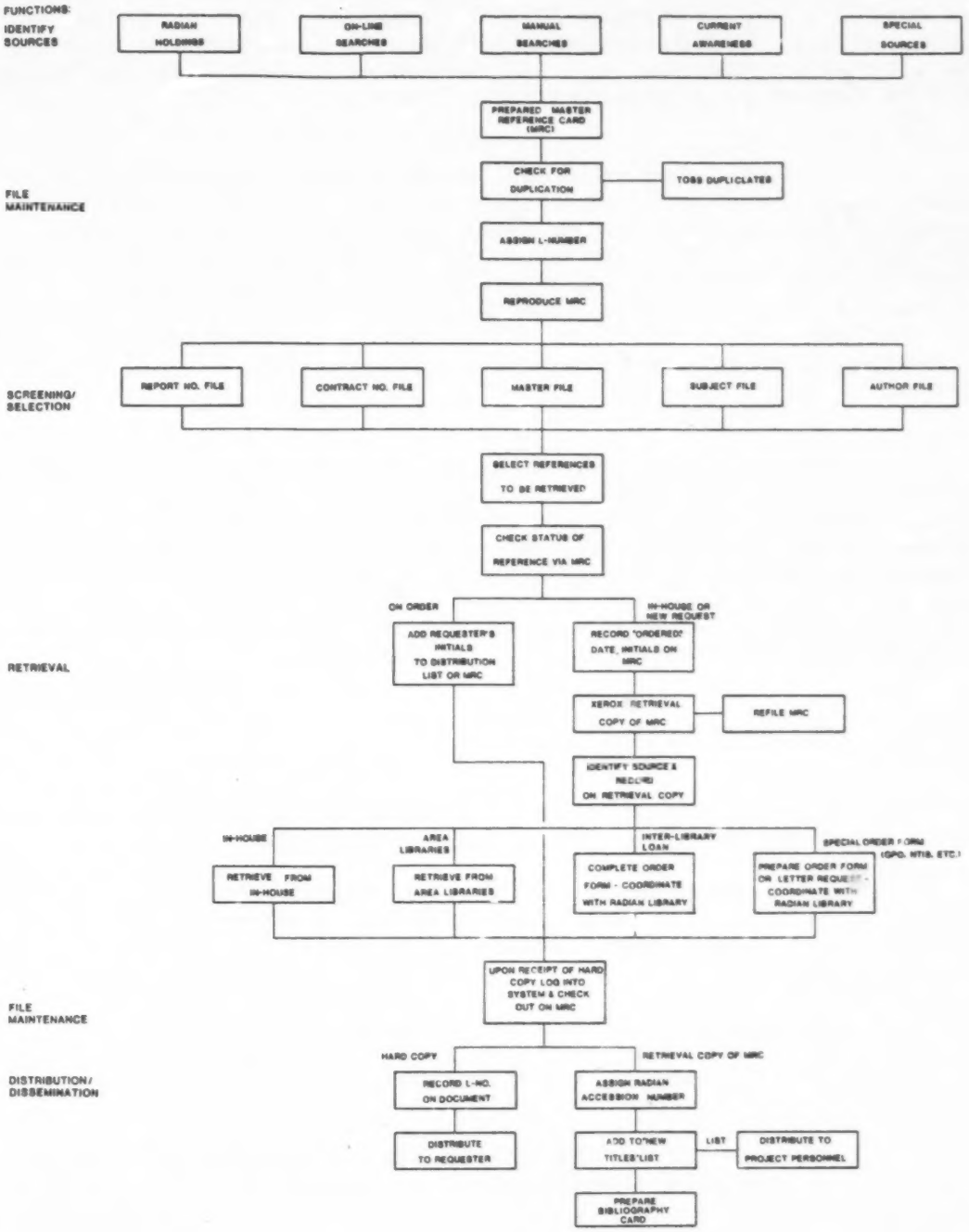

Figure 2-1. TECHNICAL INFORMATION SYSTEM

indexing system including key work references was designed to provide ready access to the technical information acquired. As a result of the information survey efforts, the low-Btu library now contains approximately 10,000 citations, with full-text copies of over 3,500 documents. Appendix A contains a list of the literature sources, special search areas and indexing terms used by Radian in assembling this library.

Several communication devices were implemented to ensure that the literature identified and entered in Radian's technical information system would reach appropriate project team members, the EPA, and other prime contractors. "New Titles" lists provide personnel an opportunity to be aware of and, if interested, request reports readily available in-house. Listings also include titles of those NTIS reports received under a special subscription search service for the subject area, "Coal Gasification."

Responsibility for maintaining awareness of certain key areas in the low-Btu data base is assigned to individual project members. All new citations added to the files are automatically routed through these personnel. Similarly, all literature identified via screening of the current technical literature is also routed directly to these persons. They, in turn, are responsible for evaluating and identifying key references within their general areas of expertise.

2.1.2 Engineering Analysis

Engineering assessment activities in this program have been geared to the following general objectives:

1) reduction of the mass of information in the technical data file to an orderly, useful environmental data base.

2) analysis of gasification and control processes, with the particular objective of planning environmental tests,

3) support of the EPA in low/medium-Btu and related technologies, as requested.

Summaries of significant engineering analyses, reports, and related activities are given on the following pages.

Environmental Assessment Data Base for Low/Medium-Btu Gasification Technology

During the first year of the low/medium-Btu gasification program, a detailed engineering assessment of available process, environmental, and control technology data for low/medium-Btu gasification and end-use technology was assembled. This was intended to 1) provide a data base for subsequent environmental and control technology assessments, 2) describe processes that are viable candidates for use as gas purification and pollution control processes in low/medium-Btu gas production facilities, and 3) identify known pollution problems and data gaps.

As additional data became available, the scope of the engineering assessment was broadened to include coal pretreatment, gasification and end-use technologies. A report summarizing the results of the expanded engineering assessment (EPA 600/7-77-125a and b) was prepared. The purpose of this report was to provide practical and up-to-date discussions of

1) the processes which can be used to produce low/medium-Btu gas from coal,

2) the constraints imposed upon those processes by the intended end uses of the product gas,

3) the air, water, and solid waste streams generated by those processes, and

4) the pollution control techniques which appear to be applicable to the control of those multimedia discharge streams.

Throughout the report, attention is focused on those processes which appear to have the highest likelihood of near-term commercialization. The following criteria were used to identify these processes:

1) applicability to low/medium-Btu gasification and utilization technologies,

2) development status,

3) energy efficiency,

4) limitations (unusual raw material needs, sensitivity to various feedstocks and operating parameters, utilization process requirements, etc.),

5) environmental impacts, and

6) capital and operating costs.

This technology screening step is of considerable importance to the overall program; it is the primary basis for establishing priorities for subsequent phases of program activity.

Both low/medium-Btu gasification and product gas utilization technologies are considered in the report. Gasification technology is assumed to include the processes required both to produce low/medium-Btu gas and to control the resulting multimedia discharge streams. The systems used to produce low/medium-Btu gas are grouped into three operations: coal pretreatment, gasification, and gas purification. There are three pollution control areas: one for air, one for water, and one for solid waste.

Each of the three operations is further divided into process modules. Each module has a defined process function and identifiable input and output streams. Utilization technology includes the processes that may use the product low/medium-Btu gas for direct combustion (boilers, furnaces, gas turbines, etc.) or as a synthesis or reducing gas.

As a result of the screening step, fourteen gasification processes out of a total population of 68 were identified

(see Table 2-1) as the most promising candidates for satisfying near-term commercial needs for low/medium-Btu gas. Similarly, the thirteen acid gas removal processes shown in Table 2-2 were identified out of a total population of 70 as those having the highest probabilities of near-term application in low/medium-Btu gasification systems. Detailed data sheets for these high probability processes as well as for processes for treating air, water and solid waste discharges are included in Volume II of the report. Volume I contains discussions of the status of technology, major operations, discharge stream control strategies, and recommendations for future program activities.

Lurgi Process Studies

During the first year of the program, information was assembled which provided a basic understanding of the Lurgi gasification process. Basic process engineering studies were made to define operating conditions and compositions of the major process and discharge streams for a Lurgi medium-Btu gasification plant. The process schematic used was an adaptation of the proposed El Paso Burnham gasification plant. Process descriptions (including a Rectisol acid gas removal unit), a material balance and a discharge stream summary were prepared for the Lurgi plant. There were two purposes for this work. One objective was to aid in preparation for test program planning at the Kosovo lignite gasification plant in Yugoslavia. This work also served as Radian's part in a joint study to provide technical support for New Source Performance Standards.

General conclusions from these studies of the Lurgi process are summarized below.

1) Sulfur compounds can be controlled by use of currently available commercial technology for acid gas removal, sulfur recovery, and tail gas cleanup.

2) The Phenosolvan process should recover 99 percent of the monohydric phenols and 50-60 percent of the polyhydric phenols from wastewater,

3) Ammonia recovery in the range of 90-95 percent is possible.

Table 2-1. PROMISING LOW/MEDIUM-BTU GASIFICATION SYSTEMS

First Group[1]	Second Group[2]	Third Group[3]
• Wellman-Galusha	• Chapman (Wilputte)	• Pressurized Wellman-Galusha (MERC)
• Lurgi	• Riley Morgan	• BGC/Lurgi Slagging Gasifier
• Woodall Duckham/ Gas Integrale		• Texaco
• Koppers-Totzek		• Bi-Gas
• Winkler		• Coalex
• Wellman Incandescent		
• Foster Wheeler/Stoic		

[1]Commercially available; significant number of units currently operating in the U.S. or in foreign countries.

[2]Commercially demonstrated in limited applications.

[3]Commercial or demonstration-scale units operating or being constructed; technology is promising and should be monitored.

Table 2-2. PROMISING ACID GAS REMOVAL PROCESSES

Chemical Solvent Processes
Monoethanolamine (MEA)
Methyldiethanolamine (MDEA)
Diethanolamine (DEA)
Diisopropanolamine (DIPA)
Diglycolamine (DGA)
Benfield
Physical Solvent Processes
Rectisol
Selexol
Purisol
Estasolvan
Fluor solvent
Combination Chemical/Physcial Solvent Processes
Sulfinol
Amisol

4) Particulate control using wash cooling and liquid scrubbing for acid gas removal appears adequate for all potential uses.

5) The distribution of trace metals is unknown but studies of metal volatility indicate that mercury, selenium, arsenic, lead, cadmium, and vanadium will tend to go overhead in the product gas along with fluorine and chlorine. Where and if they eventually leave the gas as it cools is uncertain. These species present potential environmental problems regardless of whether they remain in the gas or end up in the gas liquor or in by-product hydrocarbons.

6) The potential hazards of trace organics which are formed and their distribution in the process streams are also largely unknown. Some of the organics will obviously be highly aromatic or heterocyclic. Many known or suspected carcinogens and mutagens fall into these categories. Water and air pollution control to remove minute quantities of these compounds will be difficult to achieve.

In-Situ Coal Gasification: Status of Technology and Environmental Impact

This report, published in May 1977 (EPA 600/7-77-045), contained general discussions of the chemistry, technical problems and environmental considerations associated with in-situ gasification technology. Activities at specific U.S. and foreign in-situ projects were summarized and detailed descriptions of the technical objectives, the test approach, and results of each of these projects were provided.

Some general conclusions of an environmental nature resulting from the study are summarized below:

1) Degradation of ground water could result from

- organic contaminants in the tar produced during carbonization or gasification,

- inorganic salts or trace element loading due to dissolution of ash, and

- changes in water flow patterns or rates resulting from subsidence or interconnection of aquifers by fracturing.

2) Only limited information is available on the impact of in-situ gasification on air quality.

3) To date, no subsidence effects have been observed, but again only limited data are available on this subject.

2.2 ENVIRONMENTAL DATA ACQUISITION

Through study of the current process technology background, Radian identified significant gaps in the environmental data base for low/medium-Btu gasification. Filling these data gaps is the primary objective of the data acquisition task. Efforts in this area have been centered on two activities: development of sampling and analytical strategies, and selection and testing of appropriate data acquisition sites.

2.2.1 Sampling and Analytical Strategy

Radian has prepared numerous writings dealing with test plan development. This information presents a general approach to conducting environmental test programs. Major emphasis is placed on the steps involved in developing process descriptions and the detailed test program. The significant portions of this material have been incorporated into a comprehensive document, Guidelines for Preparing Environmental Test Plans for Coal Gasification Facilities.

The basic approach used in preparation of this guideline document was to assume there are four general areas to be addressed in a test program planning effort:

1) engineering analysis of the potential test site,

2) definition of test objectives and methods of satisfying these objectives,

3) selection of sampling methods, and

4) selection of analysis methods.

The relationship of these four test planning functions is illustrated diagrammatically on Figure 2-2.

2.2.2 Test Site Selection

One of the first steps in selecting the most applicable sites for environmental testing was to assemble a list of key organizations and personnel involved in low/medium-Btu gasification technology. This list served as a starting point for investigating test site possibilities in both the U.S. and other countries.

As of October 1977, arrangements had been made for testing at the following four sites:

1) Holston Army Ammunition Plant
Kingsport, Tennessee

2) Kosovo Combine
Pristina, Yugoslavia

3) Glen-Gery Brick Company
York, Pennsylvania

4) University of Minnesota
Duluth, Minnesota

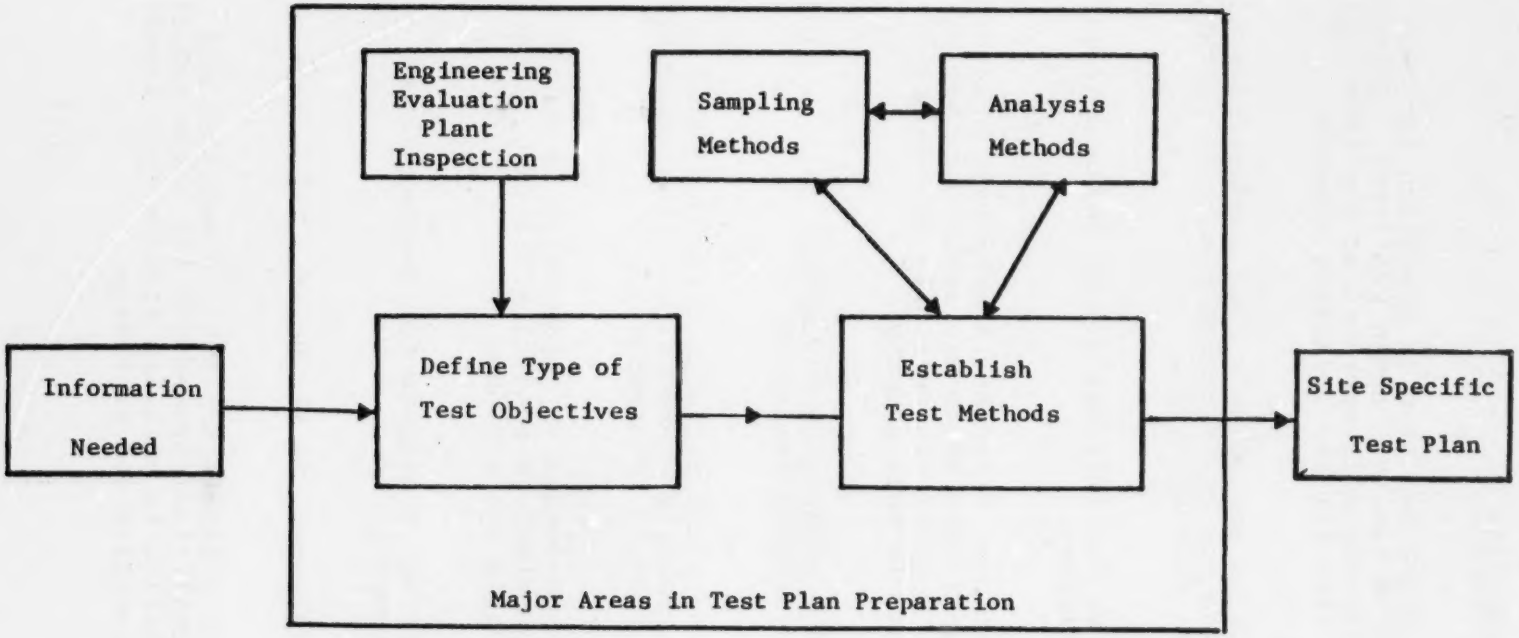

Figure 2-2. INFORMATION FLOW DIAGRAM FOR THE PREPARATION OF A SITE SPECIFIC TEST PLAN.

Holston Site

This plant has been in operation for over thirty years. The plant contains twelve Chapman gasifiers. Currently, only two gasifiers are normally operated at any time. It is an excellent test site for the following reasons:

1) It is one of only four commercial-scale low-Btu gasification plants in operation in this country.

2) The facility has a well-defined operating history.

3) It uses fixed-bed atmospheric pressure gasifiers which are representative of the gasifiers currently in commercial use in this country.

4) The plant uses bituminous coal, a widely available feedstock.

5) The plant includes a gas quenching-scrubbing system from which liquid by-products are removed.

6) It provides an opportunity to obtain particulate removal effectiveness data for a hot cyclone.

7) It was available for testing almost immediately.

The specific objectives of the Holston test program were

1) to evaluate EPA Level 1 sampling and analytical procedures for their applicability to emission streams from low-Btu gasification processes,

2) to identify the origin and fate of potentially hazardous components in a specific coal gasification plant, and

3) to obtain control technology data relating to

   - emissions from coal feed systems, and

   - the effectiveness of a hot cyclone as a particulate removal device.

The detailed test plan for the Holston site was prepared in early August 1977 and sampling was conducted in August and September 1977. Seven streams were sampled for environmental testing. In addition, total particulate loadings were measured in the hot gas cyclone inlet and outlet streams. Sampling data and the results of on-site analyses and preliminary off-site analyses are now being evaluated.

Kosovo Site

The Kosovo plant uses oxygen-blown Lurgi gasifiers to produce medium-Btu gas for an industrial complex. This plant is a desirable test site for several reasons.

1) The Lurgi process is a widely used commercial process.

2) It has successfully operated (since 1971) with a lignite feedstock.

3) It is a pressurized oxygen-blown system.

4) A Rectisol unit is used to remove H_2S from the medium-Btu gas.

Preliminary planning for a specific test program at the Kosovo

plant was initiated in June 1976 during a visit to the plant by EPA and Radian representatives. An environmental and control technology test plan for the Kosovo plant was developed by the Rudarski Institute (Belgrade, Yugoslavia), EPA and Radian. A final agreement for testing this plant was negotiated and approved in September 1977. Sampling and analysis activities at the Kosovo facility began in November 1977. While the actual sampling and analysis work will be performed by Kosovo plant personnel, Radian is providing technical personnel to assist in these activities.

Other Sites

Preliminary test plans have been developed for the Glen-Gery brick plant at York, Pennsylvania, where a Wellman-Galusha fixed-bed atmospheric gasifier is being installed, and at the University of Minnesota at Duluth where a Foster Wheeler-Stoic gasifier is scheduled to be installed by late 1978. Both of these tests will be conducted in conjunction with DOE's Gasifiers in Industry test program.

Grab Sample Analyses

During visits to several potential test sites, grab samples of selected liquid and solid discharge streams were obtained. The purpose was to apply Level 1 analytical procedures to typical gasification plant samples. Some conclusions from this random sampling and analysis effort were:

1) The major organic constituent of quench liquor obtained at Site A was phenol with lesser amounts of di- and trisubstituted components; volatile organics fell mainly in a chromatographic boiling range of 160-200°C.

2) As expected for recycled process liquids, the levels of trace elements in the Site A quench liquor equaled or exceeded the levels listed in the Federal Water Quality Standards for nearly every element. The largest deviation was shown by selenium at 4 ppm (400 times the quality standard for surface water).

3) The Site A cyclone bottom dust (from bituminous coal) appeared to consist of hollow spheres with a nominal particle diameter (d_{50}) of 170μ. Fines appeared to be sections of broken spheres. The Site C bottom dust (bituminous coal) was smaller and irregular in shape, but of comparable bulk density. The Site B dust (anthracite coal) had a particle shape comparable to the Site C dust but was more than twice as dense and was highly agglomerated.

2.3 CONTROL TECHNOLOGY ASSESSMENT

2.3.1 Stepwise Investigation of Control Needs

The ultimate goal of this program is to specify environmental control technology for low/medium-Btu gasification facilities. To reach this goal will require moving through a series of studies, tests, and assessments such as described in the following steps:

Step 1 - Gain understanding of the processes generating products, by-products, and pollutants.

Step 2 - Study the control technology now available for air, water, and solid waste pollution control.

Step 3 - Consider the nature of waste streams from priority processes and determine which streams will require analysis.

Step 4 - Analyze and characterize waste streams from typical coal conversion plants through the data acquisition program.

Step 5 - Identify pollutants in these waste streams that must be controlled if the process is to be made environmentally acceptable.

Step 6 - Specify how much each pollutant must be reduced in each stream.

Step 7 - Specify what kind of existing control technology can be used, or what type of new technology will be needed.

2.3.2 Progress to Date

At this point in the program, Radian has moved through Step 3 for many processes and has entered Step 4 (data acquisition) for a few processes now in operation. Results from current and future tests will allow activities to move into the "specification of needs" area such as will be involved in Steps 5, 6, and 7. Results from the Holston tests and subsequent tests at Glen-Gery, University of Minnesota, and Kosovo Combine will provide the first information to the program in which process and waste streams are truly characterized. The amount of cyanides or phenols in wastewater, trace elements in all waste streams, physical properties of particulates and ash, and hundreds of other pieces of data will be used to arrive at the environmental characterization of the plants being tested.

Some preliminary work has started. For instance, at Holston, tests were conducted to determine the dust collection efficiency of hot cyclones handling raw product gas. After analysis of the other samples collected there (Step 4), a period of interpretation (Step 5) will occur before moving to Steps 6 and 7.

In summary, it is anticipated that considerable progress will be made in control technology assessment activities during the next year. The rate at which this work unfolds will be dependent on the quantity and quality of data obtained from the test programs.

APPENDIX A

TECHNICAL INFORMATION SYSTEM

Table A-1. INFORMATION SOURCES USED IN GENERAL LITERATURE SEARCH

Subject	Source	Period of coverage
RADIAN HOLDINGS		
Coal conversion technologies, environmental aspects, sampling and analytical techniques	Radian holdings - OCR/ERDA literature files	Through 1975 (beginning of range depended on specific topic)
Western energy resource technologies including coal gasification	Radian holdings - EPA/ITA literature files	Through present
All pertinent topics including engineering, chemical and analytical titles	Radian Library, "Books and Reports: New Titles Received" (bi-weekly)	December 1973 - present
ON-LINE DATE BASES		
Coal gasification, phenols - water pollution/ treatment, coking - water pollution	SRIM Profile	1976 (12) - present
Coal processing and chemistry (pollution control technology covered in manual search)	Compendex (Engineering Index)	1970 - 1976 (May)
All pertinent topics plus extra effort for shift reaction and methanation	NTIS/GRA	1964 - 1976 (19)

Continued

Table A-1. INFORMATION SOURCES USED IN GENERAL LITERATURE SEARCH (Continued)

Subject	Source	Period of coverage
ON-LINE DATA BASES (Cont.)		
On-going research in coal chemistry, coal processing, acid gas cleanup, water treatment, combined cycle	SSIE	Through June 1976
Coal resources; auxiliary processes; air pollution relevant to coal gasification including H_2S, organic S, NH_3, CN^-, HCN, and related industries; water pollution control in refineries, coke plants; solid waste including tars, char, slag, ash; utilization; noise	Engineering Index	1968 - 1976 (May)
All pertinent topics	Bureau of Mines publications	1970 - present
SPECIAL SOURCES		
All pertinent topics published by EPA/ORD	ORD Publications Summary (June 1976)	Through June 1976
General	EPA-ERC/RTP (outside) Publications Bibliography, February 1976	Through 1975

Continued

Table A-1. INFORMATION SOURCES USED IN GENERAL LITERATURE SEARCH (Continued)

Subject	Source	Period of coverage
SPECIAL SOURCES (Cont.)		
Coal processing and preparation	U.S. Atomic Energy Commission, Coal Processing, Gasification, Liquefaction, Desulfurization. A Bibliography. NTIS Publication #TID-3349	1930 - 1974
All topics	Translations from the Scientific Literature - Annotated Bibliography	1974 - 1975
Selected coal gasification processes and test programs	Exxon, Evaluation of Pollution Control in Fossil Fuel Conversion Processes. EPA 650/2-74-009a-m plus Final Report. EPA Contract #68-02-0629	-
Sampling and analysis	ASTM, Annual Book of ASTM Standards	Published annually
All pertinent topics	ACA publications list	Through 1976
All pertinent topics	AIChE Publications List	Through June 1976
All pertinent topics	Publications of the Staff Members and Fellows of the Institute of Gas Technology	1941 - August 1975

Continued

Table A-1. INFORMATION SOURCES USED IN GENERAL LITERATURE SEARCH (Continued)

Subject	Source	Period of coverage
SPECIAL SOURCES (Cont.)		
EPRI sponsored reports	EPRI Publications List	Through September 1976
Survey reports on various technologies	Noyes Data Corp. Publications List	Through September 1976

Table A-2. SUMMARY OF SPECIAL SEARCHES

Subject	Source	Period of coverage
Lurgi and Rectisol processes	NTIS/GRA (on-line)	1964-1976 (Issue 10)
	Compendex	1970-1976 (April)
	Chemcon	1972-1976 (Issue 14)
Chemical costs for S recovery solvents	Contact with manufacturers	-
Sample handling for aqueous organics	Analytical Abstracts	1975
	Chemcon	1972-1976 (September)
	Chem 70/71	1970-1971
Regulations	Environmental Reporter	Through present
Evaporation ponds	Radian holdings	-

Continued

Table A-2. SUMMARY OF SPECIAL SEARCHES (Continued)

Subject	Source	Period of coverage
Dust control for coal pretreatment	Radian holdings, MRI report, RTI report	-
Solubility of gases in methanol	Radian holdings	-

Table A-3. MAJOR LOW-BTU LIBRARY KEY WORD FILING REFERENCES

Background Information and Special Sources
Coal Industry and Pre-Gasification Technology
Chemistry of Coal and Related Substances
Coal Conversion Technology
Related Technologies
Utilization
Environmental and Health Effects
Gas Purification and Pollution Control Technology
Water Treatment
Solid Waste
Waste Disposal
Sampling and Analytical Data